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**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

For new nonprovisional applications under 37 CFR 1.53(b)

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First Inventor or Application Identifier Masaki NARUSHIMA

Title CERAMIC HEATER SYSTEM AND SUBSTRATE PROCESSING APPARATUS HAVING THE SAME INSTALLED THEREIN

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**APPLICATION ELEMENTS**  
See MPEP chapter 600 concerning utility patent application contents

1.  Fee Transmittal Form (e.g. PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2.  Specification Total Sheets **38**
3.  Drawing(s) (35 U.S.C. 113) Total Sheets **8**  
**(Formals)**
4.  Oath or Declaration Total Pages **3**
- a.  Newly executed (original)
- b.  Copy from a prior application (37 C.F.R. §1.63(d))  
(for continuation / divisional w/ box 16 completed)
- i.  DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §1.63(d)(2) and 1.33(b).
5.  CD-ROM or CD-R in duplicate, large table or Computer Program (*Appendix*)
6.  Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)
- a.  Computer Readable Form (CRF)
- b. Specification or Sequence Listing on:
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16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below:

 Continuation     Divisional     Continuation-in-part (CIP) of prior application no.:

Group Art Unit:

Prior application information: Examiner:

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. Amend the specification by inserting before the first line the sentence:

 This application is a  Continuation     Division     Continuation-in-part (CIP)  
of application Serial No. Filed on This application claims priority of provisional application Serial No. Filed**18. CORRESPONDENCE ADDRESS****22850**

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## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

INVENTOR(S) Masaki NARUSHIMA

SERIAL NO: New Application

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FOR: CERAMIC HEATER SYSTEM AND SUBSTRATE PROCESSING APPARATUS HAVING THE SAME  
INSTALLED THEREIN

## FEE TRANSMITTAL

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Respectfully Submitted,

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TITLE OF THE INVENTION

CERAMIC HEATER SYSTEM AND SUBSTRATE PROCESSING

APPARATUS HAVING THE SAME INSTALLED THEREIN

CROSS-REFERENCE TO RELATED APPLICATIONS

5        This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 11-341916, filed December 1, 1999, the entire contents of which are incorporated herein by reference.

10      BACKGROUND OF THE INVENTION

The present invention relates to ceramic heater system which heats a substrate in treatments, such as CVD (Chemical Vapor Deposition) and plasma etching, and to a substrate processing apparatus having this heater system installed therein.

15      The general fabrication of semiconductor devices includes a step of performing a vacuum treatment, such as CVD or plasma etching, on a semiconductor wafer to be processed. In such a treatment, a heat treatment for heating a semiconductor wafer to a predetermined temperature is carried out. To execute such a heat treatment, a heater is buried in a substrate support member. A typical conventional heater of this type is a stainless heater.

20      25      Ceramic heaters that are hard to be corroded by halogen-base gases which are used in processing semiconductor wafers and have a high heat exchanging

efficiency have been developed recently and are  
becoming popular. Such a ceramic heater has a heat  
generating wire of a high-melting-point metal buried in  
a heater base which is a dense ceramic sintered body of  
5 AlN or the like and on the top of which a semiconductor  
wafer is to be mounted.

A heat treatment which is executed at the time of  
performing CVD, plasma CVD or the like is demanded of  
an extremely high uniform heating performance while  
10 heating a semiconductor wafer to 500°C or higher.

Further, it is required that semiconductor wafers  
should be resistant to plasma during plasma etching.

Because it is difficult to provide the desired  
uniform heating by a ceramic heater alone, which is  
15 buried in the heater base, various schemes are  
attempted to achieve the uniform heating. For example,  
the technique that is disclosed in Jpn. Pat. Appln.  
KOKAI Publication No. 272834/1995 has a fluid passage  
with a fine cross-sectional area provided between  
20 a semiconductor-wafer mounting surface of a ceramic  
heater base and a buried heater. The temperature  
differences at individual positions of the ceramic  
heater base are therefore reduced by the convection of  
a fluid flowing in the fluid passage, thereby ensuring  
25 a uniform heating temperature on the mounting surface.

There are demands for further improvement of the  
throughput in the fabrication of semiconductor devices

is demanded of and for a shorter down time at the time of maintenance of the substrate processing apparatus.

For example, a single wafer type CVD system regularly executes in-situ cleaning with a halogen-base gas and needs to lower the temperature of a ceramic heater to 150 to 500°C from a film deposition temperature of 700°C. As the conventional cooling time is about 3 hours, a shorter cooling time is demanded. The interior of the chamber is exposed to the atmosphere for maintenance or the like. The interior of the chamber is cooled to near the room temperature to facilitate the maintenance. The cooling requires a long time. It is demanded that the cooling be achieved within a short time.

The aforementioned technique disclosed in Jpn. Pat. Appln. KOKAI Publication No. 272834/1995 can cool the heater base by the flow of the fluid at the time of maintaining the processing apparatus that uses the ceramic heater. This can shorten the down time in which the apparatus is stopped.

Generally speaking, to provide a sufficient cooling performance, the cross-sectional area of the fluid passage should be increased to permit the flow of a larger amount of fluid to carry the heat out. This technique has been developed to mainly ensure uniform heating and does not provide a sufficient cooling performance. Since the technique is intended

to make the heating temperature on the mounting surface even, however, it is necessary to avoid deterioration of the heating efficiency. This is achieved by preventing the heat transmission from the heater to the 5 mounting surface from becoming lower, and requires that the cross-sectional area of the fluid passage be made as small as possible.

Therefore, the more the heating efficiency is improved, the less the performance of the cooling means 10 for the heater becomes sufficient. The conventional technique suffers a limitation to shortening the time of cooling the heater base and faces a difficulty in satisfying the demanded short cooling time.

#### BRIEF SUMMARY OF THE INVENTION

Accordingly, it is an object of the present 15 invention to provide a ceramic heater system which has a high cooling efficiency while keeping the uniform heating performance on the heating surface high, and a substrate processing apparatus in which this ceramic 20 heater system is installed.

A ceramic heater system according to this invention comprises a ceramic heater base having a substrate mounting surface formed on a top surface thereof; a heater, buried in the heater base, for 25 heating a substrate; and a fluid passage provided in the heater base below the heater, whereby the heater base is cooled by letting a fluid whose temperature is

lower than a temperature of the heater base flow in the fluid passage.

A substrate processing apparatus in which such a ceramic heater system is installed comprises a chamber whose interior can be kept in a vacuum state by an exhaust system and processing means for performing a predetermined treatment on the substrate in the chamber, and performs film deposition and etching on the substrate.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a vertical cross-sectional view exemplarily illustrating a ceramic heater system according to a first embodiment of the present

invention;

FIG. 2 is a horizontal cross-sectional view along the line A-A in FIG. 1;

5 FIG. 3 is a cross-sectional view illustrating a ceramic heater system according to a second embodiment;

FIG. 4 is a cross-sectional view showing a ceramic heater system according to a modification of the second embodiment;

10 FIG. 5 is a cross-sectional view showing a ceramic heater system according to a third embodiment;

FIG. 6 is a cross-sectional view showing a ceramic heater system according to a modification of the third embodiment;

15 FIG. 7 is a cross-sectional view showing a ceramic heater system according to a fourth embodiment;

FIG. 8 is a cross-sectional view showing a ceramic heater system according to a fifth embodiment;

FIG. 9 is a horizontal cross-sectional view along the line B-B in FIG. 8;

20 FIGS. 10A and 10B are cross-sectional views depicting a ceramic heater system according to a sixth embodiment;

FIGS. 11A and 11B are cross-sectional views depicting a ceramic heater system according to a first 25 modification of the sixth embodiment;

FIGS. 12A and 12B are cross-sectional views depicting a ceramic heater system according to a second

modification of the sixth embodiment;

FIG. 13 is a cross-sectional view of a thermal CVD system which uses a ceramic heater system 32 embodying the invention;

5 FIG. 14 is a cross-sectional view of a plasma CVD system which uses a ceramic heater system embodying the invention; and

10 FIG. 15 is a cross-sectional view showing a plasma etching system which uses a ceramic heater system embodying the invention.

#### DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings.

15 FIG. 1 is a vertical cross-sectional view exemplarily illustrating a ceramic heater system for processing a semiconductor wafer according to the first embodiment of the invention. FIG. 2 is a horizontal cross-sectional view taken along the line A-A in

20 FIG. 1.

A ceramic heater system 1 has a disk-shaped heater base 2 of ceramics and a heating resistive element (heater) 3 buried in the heater base 2 in a coil form. A fluid passage 4 is provided in the heater base 2 below the heater 3.

25 Any dense ceramics may be used for the heater base 2. Preferable ceramics for the heater base 2

include nitride ceramics, such as silicon nitride  
( $\text{Si}_3\text{N}_4$ ), aluminum nitride (AlN) and silicon aluminum  
oxy nitride (SiAlON), and aluminum oxide ( $\text{Al}_2\text{O}_3$ ).  
The top surface of the heater base 2 serves as  
5 a mounting surface 2a for a semiconductor wafer W.

The heater 3, which is a heat resistor, is buried  
in the heater base 2 in a predetermined pattern (e.g.,  
a spiral form) with its both end portions connected to  
10 terminals 5 buried in the vicinity of the peripheral  
portion of the bottom of the heater base 2. The heater  
3 is connected to a power supply 6 by wires that run  
from the terminals 5. The output of the power supply 6  
is controlled by a controller 7 based on a detection  
signal from an unillustrated thermocouple provided  
15 on the heater base 2. The semiconductor wafer W is  
thereby heated to the desired temperature. The heater  
3 is formed of metal, and can be a nichrome wire  
when the heating temperature is relatively low.  
For a high-temperature ceramic heater, however,  
20 a high-melting-point metal is preferable.  
A particularly preferable metal is tungsten (W),  
molybdenum (Mo), platinum (Pt) or an alloy of  
the mentioned metals.

As shown in FIG. 2, the fluid passage 4 has  
25 a plurality of annular portions 4a concentric to the  
heater base 2, and radial portions 4b which radially  
link adjoining annular portions 4a at four locations.

The radial portions 4b that are adjacent to one another in the peripheral direction are arranged at equidistances of  $90^\circ$ , while the radial portions 4b that are adjacent to one another in the radius direction are shifted by  $45^\circ$  from one another. Preferably, the radial portions 4b are interposed between the annular portions 4a. In this case, the radial portions 4b do not overlap the annular portions 4a. In the fluid passage, the annular portions 4a and radial portions 4b are arranged so that semiconductor wafers may be heated and cooled with high efficiency. A fluid supply hole 9, through which a fluid is supplied into the fluid passage 4, is formed in the center of the heater base 2. Two fluid discharge holes 8 are formed at opposite positions of the outermost annular portion 4a.

Moreover, the holes connecting any two adjacent circular portions are arranged at regular intervals along either circular portion. Each hole made in one of walls defining a circular portion opens to that part of the other wall of the circular portion, which is located between two adjacent holes made in the other wall of the circular portion.

Designing the fluid passage 4 this way ensures effective heat exchange and a high cooling efficiency. A fluid supply pipe 9a is connected to the fluid supply hole 9, and fluid discharge pipes 8a to the fluid discharge holes 8. Those pipes 8a and 9a are

connected to a fluid supply source 10 so that the fluid  
is circulated by an unillustrated pump or similar  
means. The temperature of the gas that is supplied  
from the fluid supply source 10 is adjusted to a  
5 predetermined temperature by a temperature adjuster 11.  
This makes it possible to maintain the uniform heating  
of the heater base 2 and perform cooling control on  
the heater base 2. A heat exchanger 12 is connected to  
the fluid discharge pipes 8a so as be able to remove  
10 the extra heat of the fluid that has become hot by  
the high-temperature heater base 2.

It is preferable that the temperature of the  
fluid which is let flow in the fluid passage 4 be  
approximately in a range of -10 to 800°C. In the case  
15 where a low-temperature fluid flows in the fluid  
passage 4, the ceramic heater base 2 may be damaged by  
a heat shock. It is therefore preferable to reduce  
the temperature of the fluid step by step by the  
temperature adjuster 11 in accordance with the heating  
20 temperature of the heater base 2 so that the excellent  
cooling efficiency is acquired within the range where  
heat-shock originated damages can be avoided. The  
step-by-step temperature reduction is accomplished by,  
for example, always setting the temperature of the  
25 fluid to a temperature lower than the temperature of  
the heater base 2 at equi-intervals from 100°C to 200°C  
and adequately lowering the temperature of the fluid

when the temperature of the heater base 2 drops.

While a gas or a liquid is available as the fluid, it is preferable to use an inactive gas in consideration of possible leakage of the fluid in the chamber against a possible damage in the heater base 2. Of course, the fluid is not limited to a gas. Preferable gases are inert gases available, such as Ar, He, Ne and N<sub>2</sub> gases, at least one of which is selectively used or a proper combination of which is used. One preferable combination is a mixed gas of Ar and He. This is because the combination of high-cost He, which has a high thermal conductivity and low-cost Ar, can ensure the adequate cooling cost performance while keeping a relatively high cooling efficiency.

From this point of view, the ratio of Ar to He is preferably 3 : 1. Alternatively, the ratio of He to Ar is 20% or more.

To use the ceramic heater system 1 thus constituted, power is supplied to the heater 3 from the power supply 6 with a semiconductor wafer W placed on the mounting surface 2a or the top surface of the heater base 2. This raises the temperature of the heater base 2 to a predetermined temperature under the control of the controller 7, thus heating the semiconductor wafer W to the predetermined temperature. As a predetermined fluid, such as a gas selected from, for example, Ar, He, Ne and N<sub>2</sub>, is let flow in the

fluid passage 4 at a predetermined flow rate at this time, the temperature controllability becomes higher so that the heater base 2 can keep the desired uniform heating performance.

5 At the time of cooling the ceramic heater system 1 down from the heating temperature, the fluid is let flow in the fluid passage 4 after power supply to the heater 3 is cut off. According to this embodiment, the heating efficiency does not decrease even if the  
10 cross-sectional area of the fluid passage 4, which differs from the fluid passage in the prior art that is located above the heater, is increased. Accordingly, the cross-sectional area of the fluid passage 4 increases, permitting a relatively large amount of  
15 fluid to flow inside. The ceramic heater system 1 is therefore cooled to a predetermined temperature in a short period of time.

A ceramic heater system according to the second embodiment of the invention will now be discussed with  
20 reference to FIG. 3 which shows the cross section of the ceramic heater system. To avoid the detailed description, like or same reference numerals are given to those components of the second embodiment which are the same as the corresponding components shown in  
25 FIG. 1. Like the first embodiment shown in FIG. 1, the second embodiment has a fluid supply source 10, a temperature adjuster 11 and a heat exchanger 12, though

these components are not shown in FIG. 3. Likewise,  
all other embodiments, but the fifth embodiment  
(FIGS. 4 to 7, FIGS. 10 to 12), have a fluid supply  
source 10, a temperature adjuster 11 and a heat  
5 exchanger 12, though these components are not shown for  
the simplicity of drawings.

In the ceramic heater system of the second  
embodiment, a heater 13 buried in the heater base 2 is  
formed of graphite or glassy carbon and is arranged in  
10 a predetermined pattern (e.g., a spiral form).

In the ceramic heater system, the coefficients  
of thermal expansion of graphite and glassy  
carbon, materials for the heater 13, are respectively 2  
to  $3 \times 10^{-6}/\text{K}$  and  $1.5 \times 10^{-6}/\text{K}$  to  $2.5 \times 10^{-6}/\text{K}$ , which  
15 are relatively close to the coefficient of thermal  
expansion of AlN of  $4.6 \times 10^{-6}/\text{K}$ , so that the heater  
base 2 can be used without being damaged even if the  
temperature is raised fast or dropped fast.

As a modification of the second embodiment shown  
20 in FIG. 4, a heater 13a having a core 14 of graphite or  
glassy carbon coated with a glassy BN layer 15 may be  
used. In this case, the glassy BN has a function of  
protecting the core 14 of graphite or glassy carbon and  
a buffer capability, thus ensuring faster temperature  
25 raising and faster temperature drop.

A ceramic heater system according to the third  
embodiment of the invention will now be discussed with

reference to FIG. 5, which shows the cross section of  
the ceramic heater system. To avoid the detailed  
description, like or same reference numerals are given  
to those components of the third embodiment which are  
5 the same as the corresponding components shown in  
FIG. 1.

According to this embodiment, an electrode 20 is  
provided between the heater 3 of the heater base 2 and  
the mounting surface 2a and a DC power supply 21 for  
10 applying a voltage to the electrode 20 is connected to  
the heater 3 via a terminal 22. The DC power supply 21  
may be replaced by a high-frequency power supply.  
This structure forms electrostatic chuck on the upper  
surface portion of the heater base 2.

As a DC voltage is applied to the electrode 20 in  
the ceramic heater system, a semiconductor wafer W to  
be mounted is electrostatically chucked to the mounting  
surface 2a of the heater base 2. This allows the  
semiconductor wafer W to be surely held even when the  
20 heater base 2 is used in the vacuum atmosphere. This  
embodiment can provide a compact structure which has  
the electrostatic chuck integrated with the ceramic  
heater.

Needless to say, an electrode may be provided  
25 at a similar position in the heater bases whose  
structures are illustrated in FIGS. 3 and 4 to add  
an electrostatic chuck capability.

In the case where a plasma treatment is carried out by using the ceramic heater of each of the above-described embodiments, a plasma-producing electrode 23 is buried in the heater base 2 as in a modification of  
5 the third embodiment shown in FIG. 6. Plasma can be produced by grounding the electrode 23 and applying high-frequency power to the opposing electrode in the vacuum atmosphere. A DC voltage is applied to the electrode provided below the counter electrode. The DC  
10 voltage functions as a bias introducing ions and flaxes into the substrate. The etching rate and the deposition rate are thereby enhanced.

High-frequency power may be applied to the electrode 23. Instead of ground the electrode 23, a DC  
15 voltage may be applied to the electrode 23 so that the electrode 23 also serves as an electrode for the electrostatic chuck.

A ceramic heater system according to the fourth embodiment of the invention will now be described with reference to FIG. 7 which shows the cross section of  
20 the ceramic heater system. To avoid the detailed description, like or same reference numerals are given to those components of the fourth embodiment which are the same as the corresponding components shown in  
25 FIG. 1.

In this embodiment, a heater base 24 is separated into two portions at the bottom surface of the fluid

supply passage 4: an upper heater base 24a in which the heater 3 is buried and a lower heater base 24b in which the fluid supply hole 9 and the fluid discharge holes 8 are formed. The upper heater base 24a and the lower  
5 heater base 24b are securely adhered together by an adhesive to be discussed later direct bond, ceramic, screws or the like. Alternatively, the upper and lower heater bases 24a and 24b may be made integral by a holder or the like which supports those heater bases  
10 24a and 24b from the side while tightly connecting them. Such an integral structure makes the fluid passage 4 airtight.

An electrode may be provided in such a way as to add an electrostatic chuck capability in the fourth  
15 embodiment too.

According to this embodiment, the separation of the heater base 24 into two parts can facilitate the formation of the fluid passage 4.

According to the ceramic heater systems of the  
20 above-described embodiments, the fluid passage is provided below the heater. Thus, the heating efficiency of the heater to heat a semiconductor wafer does not fall even if the cross-sectional area of the fluid passage is increased. Therefore, the cross-  
25 sectional area of the fluid passage can be increased to supply a relatively large amount of fluid, thereby to cool the heater base in a short period of time.

Even the provision of the fluid passage below the heater can ensure the desired uniform heating performance.

It is preferable that the fluid passage should be  
5 designed to have a plurality of concentric circular portions and a plurality of portions which link those concentric circular portions. Further, it is preferable that the fluid passage should have a fluid inlet formed in the center portion of the heater base  
10 and fluid outlets formed at end portions of the heater base. The fluid inlet can be provided at a position that is optimal in view of the positions of the heater power supply and the terminals of the temperature sensor. This structure can improve the uniform heating performance and the cooling efficiency.  
15

The temperature of the fluid which flows in the fluid passage is variable within a range of -10 to 800°C and preferably within a range of about 150 to 500°C. Of course, the temperature of the fluid can be changed  
20 in accordance with the conditions of the process. A fluid whose temperature is equal to or lower than 150°C may be used in the case of exposing the interior of the chamber to the air for the purpose of maintenance.

In the case of causing a low-temperature fluid to flow in the fluid passage to cool the ceramic heater base, the temperature of the fluid should be set  
25

properly in accordance with the temperature of the heater base to prevent the heater base from being damaged by a heat shock. Specifically, the temperature of the fluid is equal to or lower than about 75% of the 5 temperature of the heater base to be cooled. It is preferable that the temperature of the fluid should be reduced step by step in accordance with the cooling stage of the heater base. When the heater base is very hot, for example, heat-shock originated damages can be 10 prevented by always adjusting the temperature of the fluid lower than the temperature of the heater base by 100 to 200°C. In the case of exposing the interior of the chamber to the air, the heater base can be cooled down efficiently if the temperature of the fluid is set 15 lower when the temperature of the heater base drops close to 150°C.

FIG. 8 is a vertical cross-sectional view showing a ceramic heater system for processing a semiconductor wafer according to the fifth embodiment of the 20 invention. FIG. 9 is a horizontal cross-sectional view taken along the line B-B in FIG. 8. To avoid the detailed description, like or same reference numerals are given to those components of the fifth embodiment which are the same as the corresponding components 25 shown in FIG. 1.

In this embodiment, a heater base 25 is separated into two portions at the bottom surface of the fluid

passage 4. That is, an upper heater base 25a in which  
the heater 3 is buried, and a lower heater base 25b in  
which the fluid supply hole 9 is formed. As shown in  
FIG. 9, fluid discharge holes 26 are formed sideways  
5 in the upper heater base 25a so that the fluid is  
discharged into the chamber. The lower heater base 25b  
is provided with the fluid source 10 which supplies  
the fluid and the temperature adjuster 11 which adjusts  
the temperature of the fluid. This structure of  
10 the embodiment causes the fluid to be discharged into  
the chamber, eliminating the need for the flow route  
from the fluid passage 4 to the heat exchanger 12 and  
thus the heat exchanger 12. The structure is simpler  
than the structure of the above-described embodiments  
15 in which the fluid is circulated in an airtight manner  
in the cycle of the fluid source 10 to the temperature  
adjuster 11 to the fluid passage 4 to the heat  
exchanger 12 while the temperature of the fluid is  
being adjusted. However, in the structure of the fifth  
20 embodiment, some kind of fluid should flow in the fluid  
passage 4 any time including during the processing of  
the semiconductor wafer in order to prevent the gas in  
the chamber from entering the fluid passage 4. The  
upper heater base 25a and the lower heater base 25b may  
25 be adhered integrally in the same way as mentioned in  
the foregoing description of the fourth embodiment.  
Further, an electrode may also be provided in the fifth

embodiment to add an electrostatic chuck capability.

According to this embodiment, the separation of  
the heater base 25 into two parts can facilitate the  
formation of the fluid passage 4. As the fluid is  
5 discharged into the chamber, the structure becomes  
simpler.

FIG. 10A shows the horizontal cross section of  
a part of the heater base of a ceramic heater system  
for processing a semiconductor wafer according to  
10 the sixth embodiment. FIG. 10B shows the vertical  
cross section of a portion M shown in FIG. 10A.  
The illustrated example is adapted to the heater bases  
24a and 25a of the fourth and fifth embodiments.

To improve the cooling efficiency, cooling fins 27  
15 are provided on the heater-side surface of the fluid  
passage 4. The provision of the cooling fins 27 can  
increase the thermal conductivity to the fluid.  
Although two cooling fins 27 are shown, the number of  
the cooling fins is not limited to this quantity and  
20 a greater number of the cooling fins may be provided.

FIGS. 11A and 11B show a first modification of the  
sixth embodiment in which cooling fins 28 are provided  
on the surfaces of the fluid passage 4 perpendicular to  
the heater's side surfaces at positions relatively  
25 close to the heater. The cooling fins 28 demonstrate  
the same effect as the cooling fins 27 of the sixth  
embodiment. FIGS. 12A and 12B shows a second

modification of the sixth embodiment in which the fluid passage has a irregularity surface with multiple crating and undulations. The irregularity surface increases the surface area to thereby increase the  
5 thermal conductivity to the fluid.

This embodiment is not limited to the provision of the aforementioned cooling fins or irregularity surface, but the heater-side surface of the fluid passage 4 may be designed in any shape as long as the  
10 surface area of the fluid passage 4 is increased. For example, the heater-side surface of the fluid passage 4 may have a irregularity surface of a sawtooth shape to improve the thermal conductivity to the fluid.  
15

A description will now be given of a method of producing such a heater base.

First, a ceramic powder is put in a mold set in a press-molding machine and premolding is performed. Then, a continual recess is provided on the surface of the premolded article in accordance with the heater  
20 pattern. Next, the heater with terminals connected to both ends is retained in the recess, a ceramic powder is further put in the recess and is subjected to unconfined press molding, thus molding a disk-shaped article. The obtained article is sintered by hot  
25 pressing or the like, thus molding a first presintered body.

Subsequently, a ceramic powder is likewise

subjected to unconfined press molding, thus molding  
a disk-shaped article, which is in turn sintered by  
hot pressing or the like, thus molding a second  
presintered body. Then, a groove corresponding to  
5 the fluid passage is made in the top surface of  
the second presintered body by an adequate method, such  
as sand blasting or etching. Further, a fluid supply  
hole and fluid discharge holes are formed. Finally,  
the first presintered body and the second presintered  
10 body are adhered hot direct bond by using an adhesive  
of glass, such as YSiAlON-based glass. While it is  
preferable to perform sintering by hot pressing,  
atmospheric pressure sintering may be used as well.  
Hot isostatic pressing (HIP) may be executed after  
15 atmospheric pressure sintering.

A description will now be given of a substrate  
processing apparatus in which a ceramic heater system  
having the above-described structure is installed.

FIG. 13 is a cross-sectional view of a thermal CVD  
20 system which uses a ceramic heater system 32 embodying  
the invention. This thermal CVD system 30 has a nearly  
cylindrical chamber 31 designed in an airtight manner.  
A semiconductor wafer W, a work to be processed, is  
supported horizontally in the chamber 31 and the  
25 ceramic heater system 32 which heats the semiconductor  
wafer W is supported on cylindrical support members 33.  
Provided on the peripheral edge of the heater base 2 is

a guide ring 34 for guiding the semiconductor wafer W.

The ceramic heater system 32 is constructed in quite the same way as the ceramic heater system 1 shown in FIG. 1. That is, the heater 3 is buried in the 5 ceramic heater base 2 and the fluid passage 4 is provided below the heater 3. Both end portions of the heater 3 are connected to the terminals 5 buried in the vicinity of the peripheral portion of the bottom of the heater base 2. The wires extending from the 10 terminals 5 run inside the support members 33 to be connected to the power supply 6 whose output is controlled by the controller 7.

A shower head 35 is provided on a ceiling 31a of the chamber 31. Multiple gas discharge holes 36 for discharging a gas toward the semiconductor wafer W n the ceramic heater system 32 are formed in the shower head 35. A gas inlet 37 is formed in the upper portion of the shower head 35. The gas inlet 37 is connected to a cleaning-gas feeding mechanism 39 and a process- 20 gas supply mechanism 40 via a gas feeding pipe 38.

The cleaning-gas supply mechanism 39 has a cleaning gas source for supplying a  $\text{ClF}_3$  gas, for example, as a cleaning gas, so as to ensure regular in-situ cleaning of the interior of the chamber 31. 25 The process-gas supply mechanism 40 has, for example, a  $\text{TiCl}_4$  gas source,  $\text{NH}_3$  gas source, Ar gas (dilution gas) source and so forth in the case where a film to be

deposited is a TiN film, or has a WF<sub>6</sub> gas source, SiH<sub>2</sub>Cl<sub>2</sub> gas source, Ar gas source and so forth in the case where a film to be deposited is a WSi film.

Connected to a bottom wall 31b of the chamber 31  
5 is an exhaust pipe 41 which is connected to an exhaust system 42 including a vacuum pump. As the exhaust system 42 is activated, the interior of the chamber 31 can be depressurized to a predetermined degree of vacuum.

10 To deposit a predetermined thin film on the semiconductor wafer W using this substrate processing apparatus, first, the semiconductor wafer W is loaded into the chamber 31 and is placed on the mounting surface 2a of the ceramic heater system 32. The  
15 chamber 31 is discharged to the vacuum state by the exhaust system 42. Then, the heater base 2 is heated by the heater 3 up to, for example, about 500 to 700°C, thereby heating the overlying semiconductor wafer W to a predetermined temperature. Then, the process gas is supplied into the chamber 31 from the process-gas supply mechanism 40 via the gas feeding pipe 38 and  
20 film deposition is performed while keeping the internal pressure of the chamber 31 to a predetermined pressure.

In this case, the temperature controllability is  
25 enhanced by feeding a gas selected from, for example, Ar, He, Ne and N<sub>2</sub>, allowing the heater base 2 to keep the desired uniform heating performance.

DISCLOSURE MADE PUBLIC

After film deposition is carried out on a predetermined number of semiconductor wafers W in this manner, the semiconductor wafers are removed from the chamber 31 and the ceramic heater system 32 is cooled  
5 to about 150 to 500°C. Then, the cleaning gas, e.g., ClF<sub>3</sub> gas, is supplied into the chamber 31 to perform in-situ cleaning of the chamber 31. At this time, the fluid is let flow in the fluid passage 4 after power supply to the heater 3 is cut off. In this case,  
10 the cross-sectional area of the fluid passage 4 can be increased to permit the flow of a relatively large amount of fluid. The ceramic heater system 32 can therefore be cooled to 150 to 500°C in a short period of time. In the case of exposing the interior of the  
15 chamber 31 to the air for the purpose of maintenance or the like, the internal temperature in the chamber 31 should be reduced to near the room temperature.  
The temperature can be lowered so in a short period of time.

20 FIG. 14 is a cross-sectional view of a plasma CVD system which uses a ceramic heater system embodying the invention.

While the schematic structure of this plasma CVD system 50 is similar to the structure of the thermal CVD system shown in FIG. 13, the plasma CVD system 50  
25 has an insulating member 43 provided between the ceiling 31a and a side wall 31c of the chamber 31 with

the ceiling 31a connected via a matching circuit 44 to a high-frequency power supply 45. As high-frequency power of, for example, 13.56 MHz is supplied to the shower head 35 from the high-frequency power supply 45,  
5 the shower head 35 serves as an upper electrode.

A lower electrode 51 for producing plasma is buried in the heater base 2 of the ceramic heater system 32 above the heater 3. A DC power supply 53 is connected via a terminal 52 to the lower electrode 51  
10 which also serves as an electrostatic chuck electrode. The plasma CVD system 50 deposits, for example, a Ti film.

In this case, the process-gas supply mechanism 40 has, for example, a  $TiCl_4$  gas source,  $H_2$  gas source, Ar  
15 gas (dilution gas) source and so forth. The other structure is the same as the thermal CVD system shown in FIG. 13, so that to avoid the redundant description, like or same reference numerals are given to the corresponding components.

20 To deposit a predetermined thin film on the semiconductor wafer W using this substrate processing apparatus, first, the semiconductor wafer W is loaded into the chamber 31 and is placed on the mounting surface of the ceramic heater system 32.

25 Then, the heater base 2 is heated by the heater 3 up to, for example, about 500 to 700°C to heat the overlying semiconductor wafer W to a predetermined

temperature. While the semiconductor wafer W is being heated up, the chamber 31 is discharged to the vacuum state by the exhaust system 42.

Then, the process gas is supplied into the chamber 5 31 from the process-gas supply mechanism 40 via the gas feeding pipe 38 and high-frequency power is supplied to the shower head 35 that serves as the upper electrode from the high-frequency power supply 45. As a result, a high-frequency electric field is produced between the 10 shower head 35 and the electrode 23 and plasma is produced in the process-gas containing atmosphere.

At this time, a DC voltage is applied to the electrode 51 from the DC power supply 52 so that the semiconductor wafer W is electrostatically chucking on the surface of the heater base 2. Because the volume resistance of the heater base 2 varies in accordance with the temperature when such electrostatic capability is provided, the material whose resistance indicates an electrostatically chuckable property at the heating 15 temperature is used for the heater base 2. In this case, the temperature controllability is enhanced by feeding a gas selected from, for example, Ar, He, Ne and N<sub>2</sub>, allowing the heater base 2 to have the desired 20 uniform heating performance.

After film deposition is carried out on a predetermined number of semiconductor wafers W, the semiconductor wafers are carried out from the chamber 31

and the ceramic heater system 32 is cooled to about 150 to 500°C, preferably to 200 to 300°C, to perform in-situ cleaning of the chamber 31, as done in the case of plasma CVD.

5 As described above, the cross-sectional area of the fluid passage 4 is increased, permitting the flow of a relatively large amount of fluid. The ceramic heater system 32 can therefore be cooled to 150 to 500°C quickly. The internal temperature of the chamber 31  
10 can be lowered to room temperature quickly by exposing the interior of the chamber 31 to the atmosphere for the purpose of maintenance or the like.

FIG. 15 is a cross-sectional view showing a plasma etching system which uses a ceramic heater system  
15 embodying the invention.

While the schematic structure of the plasma etching system 60 is similar to the structure of the plasma CVD system shown in FIG. 15, an etching-gas supply mechanism 61 is provided in place of the  
20 process-gas supply mechanism 40 because an etching gas is supplied. The etching gas, which varies depending on a film to be etched, may be a fluorine-contained gas, such as CF<sub>4</sub> gas, and the etching-gas feeding mechanism 61 is provided with a source for such an  
25 etching gas. The other structure is approximately the same as that of the plasma CVD system, so that to avoid the redundant description, like or same reference

numerals are given to the corresponding components.

According to this etching system, the temperature  
of the heater base 2 can be controlled to a  
predetermined with a high precision by the heater 3  
5 buried in the ceramic heater system 32 and the fluid  
that flows in the fluid passage 4, thus permitting  
the temperature of the semiconductor wafer W to  
be uniformly kept at a predetermined temperature.

In the case of exposing the interior of the chamber 31  
10 to the air, the heater base 2 can be cooled fast by  
causing the fluid to flow in the fluid passage 4  
provided below the heater 3. In the plasma etching  
system 60, high-frequency power may be supplied to the  
lower electrode 51 as well as the shower head 35.

15 Needless to say, the systems illustrated in  
FIGS. 13 and 15 may use the ceramic heater system of  
each of the above-described embodiments.

It should be apparent to those skilled in the art  
that the present invention is not limited to the above-  
20 described embodiments but may be modified in various  
other forms without departing from the spirit or scope  
of the invention.

For example, the shapes of the fluid passages are  
to be considered as illustrative and not restrictive  
25 and may take other shapes. Further, the illustrated  
heaters of the individual embodiments are likewise to  
be considered as illustrative and not restrictive and

other types may be used as well. While the typical pattern of the heater is a spiral form, it is in no way restrictive. Although the foregoing description of the individual embodiments has been given of the case where  
5 the ceramic heater system of the invention is adapted to thermal CVD, plasma CVD and plasma etching, the invention is not limited to those cases but may be adapted to other treatments, such as ashing. A work to be processed is not limited to a semiconductor wafer,  
10 but other substrates may be used as well.

As apparent from the foregoing description, when the ceramic heater system embodying the invention is installed in a CVD system, an etching system or the like, the down time thereof can be shortened. It is  
15 also possible to ensure the desired uniform heating performance even if the fluid passage is provided below the heater.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore,  
20 the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.  
25

WHAT IS CLAIMED IS:

1. A ceramic heater system-comprising:

a ceramic heater base having a substrate mounting surface formed on a top surface thereof;

5 a heater, buried in said heater base, for heating a substrate; and

a fluid passage provided in said heater base below said heater,

10 whereby said heater base is cooled by letting a fluid whose temperature is lower than a temperature of said heater base flow in said fluid passage.

2. The ceramic heater system according to claim 1, wherein said fluid passage has a plurality of concentric circular passage portions and a plurality 15 of penetration passage portions connecting the circular portions passage, and any adjacent two of the penetration passage portions are not aligned in a radial direction.

3. The ceramic heater system according to claim 2, wherein the penetration passage portions connecting any two adjacent circular portions are arranged at regular intervals along either circular portion, and each penetration passage portions made in one of walls defining a circular portion opens to that 25 part of the other wall of the circular portion, which is located between two adjacent penetration passage portions made in the other wall of the circular

portion.

4. The ceramic heater system according to  
claim 2, wherein said fluid passage has a fluid inlet  
in a lower portion of said heater base and fluid  
outlets at end portions of said heater base.  
5

5. The ceramic heater system according to  
claim 3, wherein said fluid which flows in said fluid  
passage is at least one gas selected from Ar, He, Ne  
and N<sub>2</sub> gases or a mixed gas thereof.

10 6. The ceramic heater system according to  
claim 5, wherein said fluid is a mixed gas of Ar  
and He.

15 7. The ceramic heater system according to  
claim 1, wherein a ratio of H<sub>2</sub> flow rate to Ar flow  
rate is 20% or more.

8. The ceramic heater system according to  
claim 1, wherein a temperature of said fluid which  
flows in said fluid passage ranges is adjusted to be  
lower than a then temperature of said heater base by  
20 100 to 200°C.

9. The ceramic heater system according to  
claim 1, wherein said heater has a high-melting-point  
metal patterned in such a coil form as to evenly  
generate heat in said heater base and two zones.

25 10. The ceramic heater system according to  
claim 1, wherein said heater is formed of graphite or  
glassy carbon shaped in such a pattern as to evenly

generate heat in said heater base.

11. The ceramic heater system according to  
claim 9, wherein said heater has glassy boron nitride  
coated on an outer surface of graphite or glassy carbon  
5 of which said heater is formed.

12. The ceramic heater system according to  
claim 1, further comprising:

an electrode buried in said heater base above said  
heater; and

10 a DC power supply for applying a DC voltage to  
said electrode,

whereby applying said DC voltage to said electrode  
causes said substrate mounted on said mounting surface  
to be electrostatically chucked.

15 13. The ceramic heater system according to  
claim 1, further comprising:

a fluid source for supplying a fluid to said fluid  
passage;

20 a temperature adjuster for adjusting a temperature  
of said fluid supplied from said fluid source within  
a range of -10 to 800°C and causing said fluid to flow  
into said fluid passage; and

a heat exchanger for removing coarse heat of said  
fluid raised by said heater base,

25 whereby said fluid is circulated in a cycle of  
said fluid source to said temperature adjuster to said  
fluid passage to said heat exchanger while said

temperature of said fluid is being adjusted.

14. The ceramic heater system according to  
claim 1, further comprising heat-discharging fins on  
a heater-side surface of said fluid passage.

5       15. The ceramic heater system according to  
claim 1, further comprising heat-discharging fins on  
both side surfaces of said fluid passage with respect  
to a heater side and at positions closer to said  
heater.

10      16. The ceramic heater system according to  
claim 1, wherein heater-side inner surface which is  
said fluid passage has a roughened irregularity  
surface.

15      17. The ceramic heater system according to  
claim 2, wherein said fluid passage has a fluid  
inlet formed in a lower portion of said heater base  
and a plurality of fluid outlets formed through  
circumferential side walls of said heater base.

20      18. A ceramic heater system comprising:  
an upper heater base of ceramics having a  
substrate mounting surface formed on a top surface  
thereof and a groove formed at a bottom surface to  
serve as a fluid passage;  
25      a lower heater base of ceramics closely adhered to  
a bottom side of said upper heater base, thereby making  
said groove airtight; and  
          a heater, buried in said upper heater base, for

heating a substrate,

whereby said heater base is cooled by causing a fluid having a temperature lower than temperatures of said upper and lower heater bases to flow in said fluid passage.

5 19. A substrate processing apparatus comprising:

a chamber whose interior can be kept in a vacuum state by an exhaust system;

10 a ceramic heater system, placed in said chamber, for heating a substrate mounted thereon; and

processing means for performing a predetermined treatment on said substrate in said chamber, said ceramic heater system including,

15 a ceramic heater base having a substrate-mounting surface formed on a top surface thereof,

a heater, buried in said heater base, for heating said substrate, and

20 a fluid passage provided in said heater base below said heater, whereby said heater base is cooled by letting a fluid whose temperature is lower than a temperature of said heater base flow in said fluid passage.

25 20. The substrate processing apparatus according to claim 19, wherein said processing means includes:

a process-gas supply mechanism for feeding a process gas; and

a shower head, provided in said chamber at

a ceiling thereof, for introducing said process gas from said process-gas supply mechanism,

whereby a film is formed on said substrate by a reaction of said process gas.

5        21. The substrate processing apparatus according to claim 20, further comprising:

a high-frequency power supply, connected to said shower head, for electrically isolating said shower head and applying high-frequency power to said shower head,

10        whereby applying said high-frequency power produces plasma in said chamber with said process gas supplied inside from said shower head and said film is formed on said substrate by a reaction of said process gas with said plasma.

15        22. The substrate processing apparatus according to claim 19, wherein said processing means includes:

an etching-gas feeding mechanism for feeding an etching gas; and

20        an electrically isolated shower head, provided in said chamber at a ceiling thereof, for introducing said etching gas from said etching-gas supply mechanism;

25        a high-frequency power supply, connected to said shower head, for applying high-frequency power to said shower head,

whereby applying said high-frequency power produces plasma in said chamber with said etching gas

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supplied inside from said shower head and said film is formed on said substrate by a reaction of said etching gas with said plasma.

ABSTRACT OF THE DISCLOSURE

A ceramic heater system has a ceramic heater base having a substrate-mounting surface formed on the top surface thereof and a heater, buried in the heater base, for heating a substrate. A fluid passage is formed buried in the heater base below where the heater is buried. The heater base is cooled as a fluid whose temperature is lower than the temperature of the heater base is let flow in the fluid passage. A substrate processing apparatus has the ceramic heater system installed in a process chamber whose vacuum state can be maintained, a gas supply mechanism for feeding a gas into the process chamber, and a power supply. The substrate processing apparatus performs a heat treatment, etching and film deposition on a substrate placed in the process chamber.

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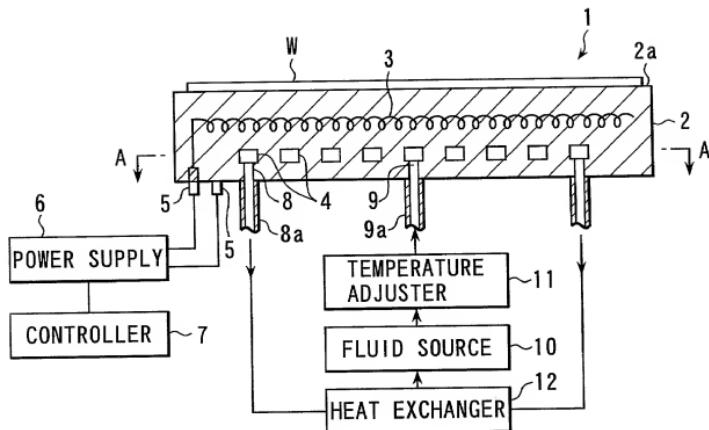


FIG. 1

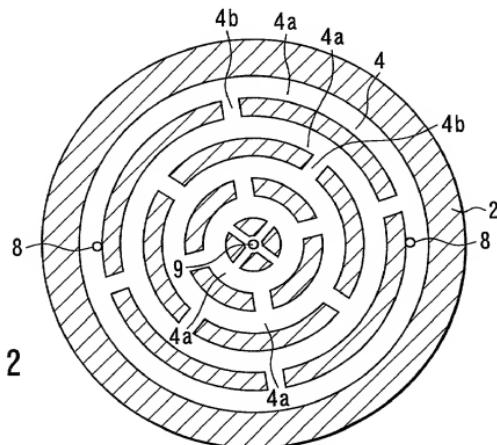


FIG. 2

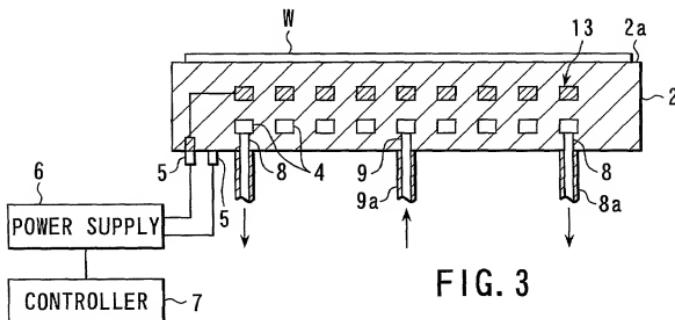


FIG. 3

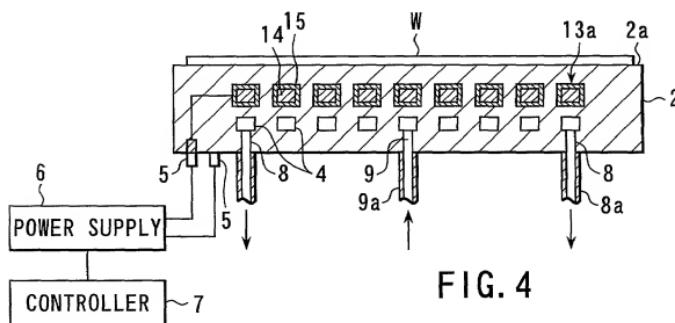


FIG. 4

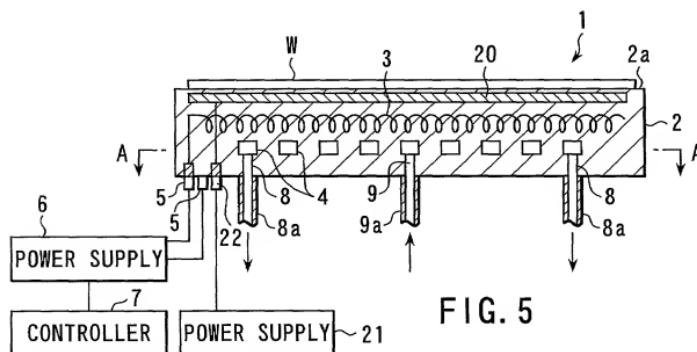


FIG. 5

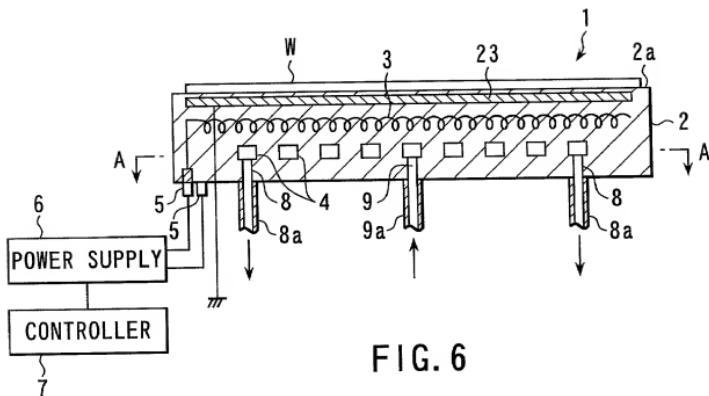


FIG. 6

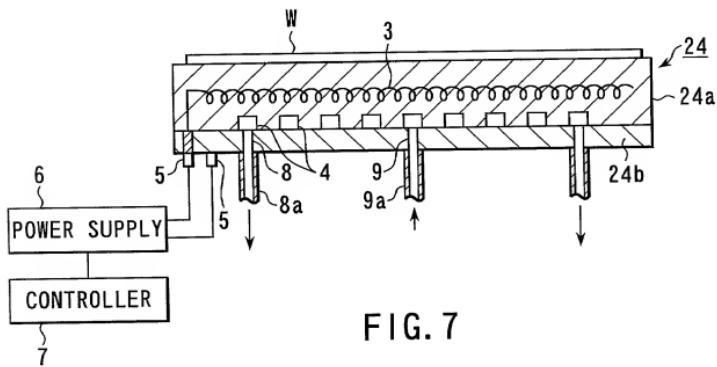


FIG. 7

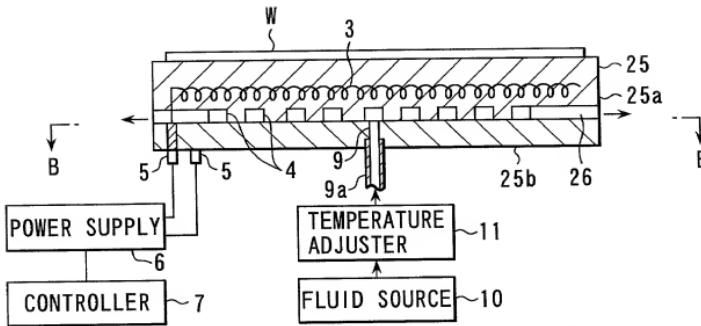


FIG. 8

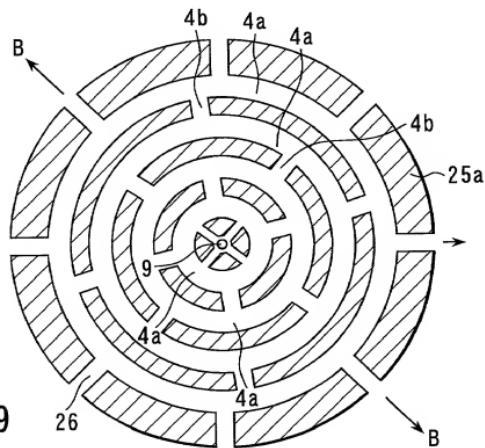


FIG. 9

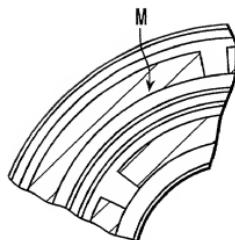


FIG. 10A

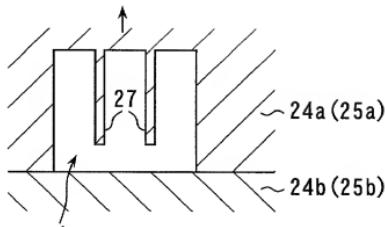


FIG. 10B

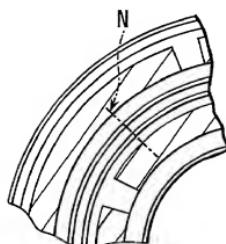


FIG. 11A

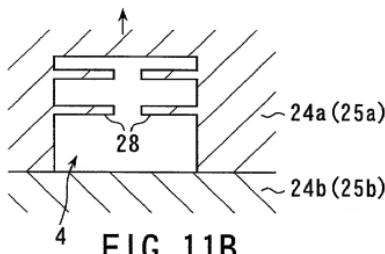


FIG. 11B



FIG. 12A

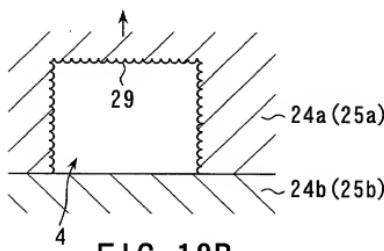


FIG. 12B

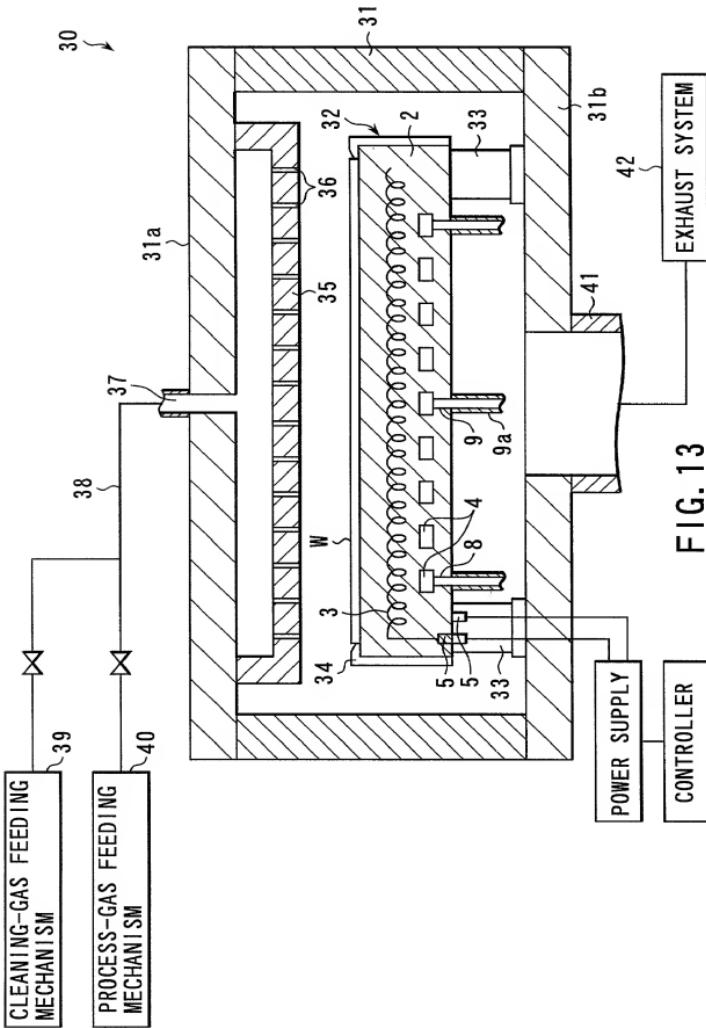


FIG. 13

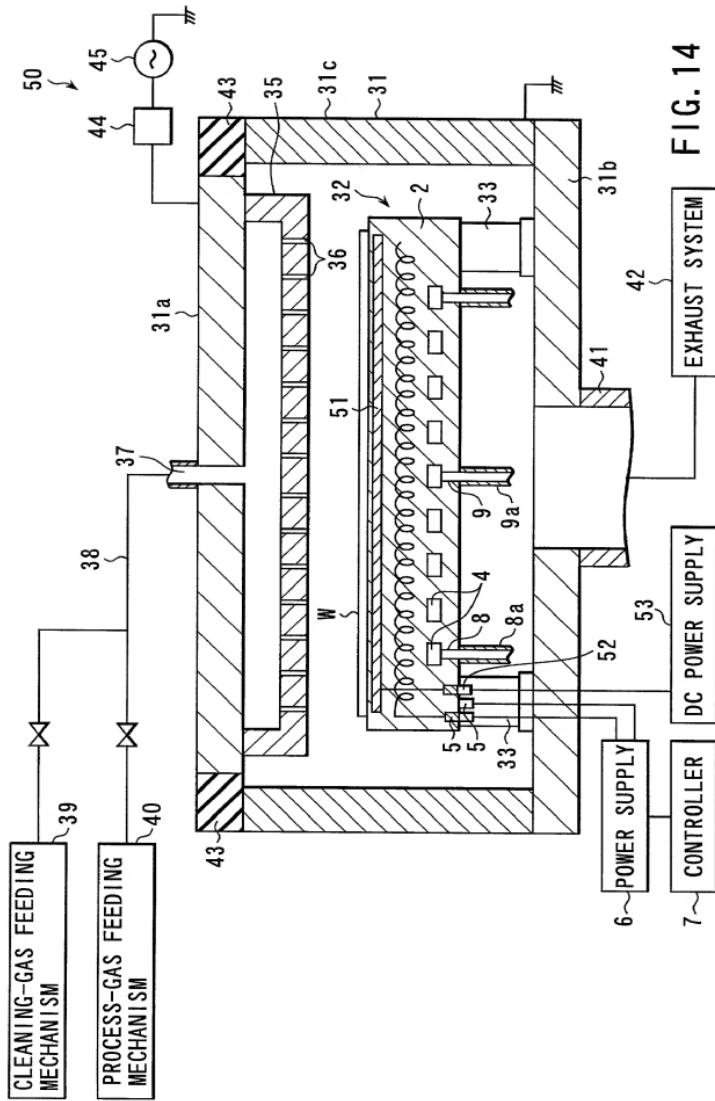


FIG. 14

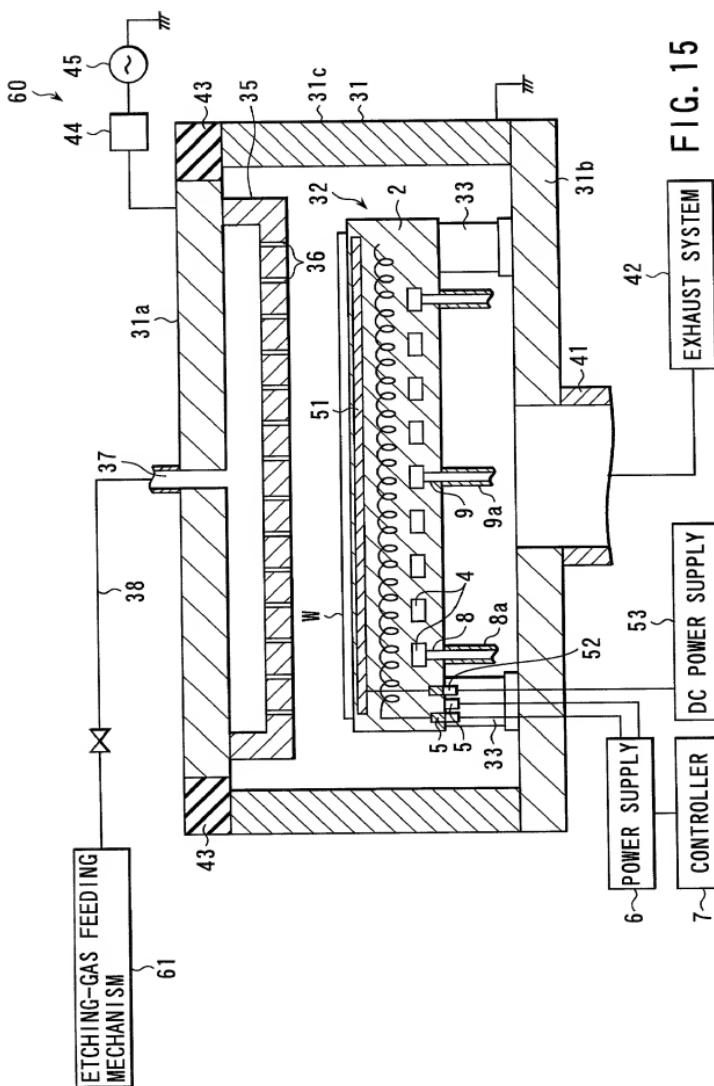


FIG. 15

Declaration Power of Attorney For Patent Application  
特許出願宣言  
Japanese Language Declaration

私は、下欄に氏名を記載した発明として、以下の通り宣言する：

私の住所、郵便の宛先および国籍は、下欄に氏名に統いて記載したとおりである。

名称の発明に關し、請求の範囲に記載した特許を求める主題の本来の、最初にして唯一の発明者である（一人の氏名のみが下欄に記載されている場合）か、もしくは本来の、最初にして共同の発明者である（複数の氏名が下欄に記載されている場合）と信じ、

セラミックスヒータシステム及びそれを搭載する基板処理装置

その明細書を  
(該当するほうに印を付す)

凶 ここに添付する。

\_\_\_\_月\_\_\_\_日に

出願番号第\_\_\_\_\_号として  
提出し、\_\_\_\_月\_\_\_\_日に補正した。  
(該当する場合)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

CERAMIC HEATER SYSTEM AND  
SUBSTRATE PROCESSING APPARATUS  
HAVING THE SAME INSTALLED THEREIN

The specification of which  
(check one)

is attached hereto.

was filed on \_\_\_\_\_  
as Application Serial No. \_\_\_\_\_ and was amended on \_\_\_\_\_

(if applicable)

私は、前記のとおり補正した請求の範囲を含む前記明細書の内容を検討し、理解したことを陳述する。

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37部第1章第56条(a)項に従い、本願の審査に所要の情報を開示すべき義務を有することを認める。

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

## Japanese Language Declaration

私は、合衆国法典第35部第119条、第172条、又は第365条に基づく下記の外国特許出願又は発明者証出願の外国優先権利益を主張し、さらに優先権の主張に係わる基礎出願の出願日前の出願日を有する外国特許出願又は発明者証出願を以下に明記する：

I hereby claim foreign priority benefits under Title 35, United States Code Sec. 119, Sec. 172 or Sec. 365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

### Prior foreign application(s)

先の外国出願

			Priority Claimed 優先権の主張	
11-341916 (Number) (番号)	JAPAN (Country) (国名)	01/12/1999 (Day/Month/Year Filed) (出願年月日)	Yes あり	No なし
			<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>

私は、合衆国法典第35部第120条に基づく下記の合衆国特許出願の利益を主張し、本願の請求の範囲各項に記載の主題が合衆国法典第35部第112条第1項に規定の態様で先の合衆国出願に開示されていない限りにおいて、先の出願の出願日と本願の国内出願日又はPCT国際出願日の間に公表された連邦規則法典第37部第1章第56条(a)項に記載の所要の情報を開示すべき義務を有することを認める。

I hereby claim the benefit of Title 35, United States Code, Sec. 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Sec. 112, I acknowledge the duty to disclose any material information as defined in Title 37, Code of Federal Regulations, Sec. 1.56 (a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況: 特許可済、係属中、放棄済)
(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況: 特許可済、係属中、放棄済)

私は、ここに自己の知識に基づいて行った陳述がすべて真実であり、自己の有する情報及び信ずるところに従つて行った陳述で真実であると信じ、更に故意に虚偽の陳述等を行った場合、合衆国法典第18部第1001条により、罰金もしくは禁固に処せられるか、又はこれらの刑が併科され、又はかかる故意による虚偽の陳述が本願に付随して付与される特許の有効性を損なうことがあることを認識して、以上の陳述を行ったことを宣言する。

I hereby declare that all statements made herein of my own knowledge are true; and further that all statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

# Japanese Language Declaration

(日本語宣言書)

委任状:私は、下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。  
(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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